AMERICAN

RAILROAD JOURNAL,

AND

MECHANICS' MAGAZINE.

No. 12. Vol. III. New Series. | DECEMBER 15, 1839. | Whole No. 348. Vol. IX.

We think that we cannot better close this volume of our Journal than by offering some remarks on the present state of the Profession, and taking a retrospective view of the operations of the last year, and saying some few words on our own labors and future course.

The attempt to form an Institution of Civil Engineers, has, we are sorry to say, failed. We are not, however, without hopes that another effort, more successful, will soon be made. We have heard a variety of opinions on this important project and, earnestly as we desire its success, we must admit that there are difficulties in the way, which it is much easier to point out than to overcome. In the first place it seems impossible to fix on any place where the leading members of the Profession could meet even once a year, far less every week, as in London. The public works of the United States are scattered over such an immense extent of country, that there is probably no point where even half a dozen Engineers, in charge of as many works, could meet even monthly. If we are right in this view, it is evident that the plan which succeeds so well in England, or rather in London, is not adapted without modification to this country. Then again the distinction between Members and Associates would lead to endless contention, though all will admit that some such division is both necessary and proper; but where to draw the line is the grand question. They who have held the rod, have carried the compass and level, have surveyed hundreds of miles for railroads and canals, and superintended the construction of not a few, are not pleased with the idea of being ranked with those who having failed as lawyers, doctors, storkeepers or office hunters "turn their attention," as the phrase is, to Civil Engineering, and who, in only too many instances, have at once received appointments to which they should have looked after five or six years arduous service in the field in the various grades of the Profession. More than one of our readers could with-

out much difficulty point out men in the situation of Residents or even higher, who would be puzzled if directed to take the Goniometer into their own hands and run out a curve of a given radius to join two tangents given in position, while the same feat constitutes one of the very easiest duties of their Assistants—the unpresuming title of those who do almost everything. There is a very large class of Assistants in the United States who from want of education or subsequent aversion to study or both, are unable to reach the highest stations of the Profession to which their long experience and practical skill fully entitle them. It is only when acting under men who combine liberal and scientific attainments with the proper experience, that this large class of eminently useful Engineers can ever attain their deserts, and it does appear reasonable to suppose, that they would derive great advantages from a well constituted Institution, where their industry skill and perseverance would be honorably registered by those who are alone capable of appreciating them. On the other hand, young men of superior talent or acquirements have only to offer original communications to the Institution, to be immediately known, and to be at once installed into the very position to which they are by their merits entitled, being neither ruined by injudicious flattery nor chilled by neglect. How different are the means by which a young Engineer now seeks to rise in his profession, on the Government works, in which are included nearly all the works of this country. His political creed, and the number of votes he and his friends can command, would far outweigh the professional claims of a rival who might unite in himself the genius of all the Engineers of the age; and this is the grand obstacle to the advancement of the Profession in the United States.

We will briefly allude to the manner in which many works are "got up," more especially in the Western States. A "celebrated Engineer" is employed to survey a railroad from 100 to 500 miles long; he makes a "highly favorable report" to the Legislature, on the strength of which they "authorise a loan" and "locate the line," though it is known to every well informed man in the State, that the work cannot be put into operation for less than 3 or 4 times the original estimate, and when it is capable of demonstration, that the country cannot possibly furnish business enough to keep the work in repair and pay interest on the loans, far less pay anything towards diminishing the debt, until the population has increased at least ten fold—say in from 50 to 100 years. Now it is obvious, that such men as Brunel, Stephenson, Walker, and a host of others in England, and we are proud to say, not a few in this country, whom we do not feel ourselves at liberty to name, are found utterly impracticable in such cases, and they are consequently avoided with as much care by the projectors of works to be built on the credit of the government, as they are zealously sought for by those who project works to be executed by the expenditure of their own actual capital. The evil of employing men incompetent from want of education, practice and character eventually recoils on the State; hence the financial difficul-

ties of all the States who have largely embarked in the construction of public works.

The State of New York furnishes some very instructive examples. By dint of much management a law was passed some years since, that, if a certain canal could be made for a million of dollars, it should be forthwith undertaken by the State. An Engineer was immediately employed to survey the route, and he reported, that the work could be constructed for nine hundred and ninety odd thousand dollars, though this was only at the rate of one half the actual cost of a similar canal, presenting fewer Engineering difficulties, which had just been completed. The insufficiency of the estimate must have been as well known then, as now, still, the law had passed and the Engineer had reported "favorably," so the million was spent, and a million and a half more was then required to complete the canal in the cheapest manner. Three years after handing in an estimate for the enlargement of the Erie canal, the following reasons are given for requiring 100 per cent additional. "A uniform plan" was not "adopted in the estimates" "and not much reflection had probably been bestowed on the particular manner in which the work should be done" (Assem. Doc. No. 339, p. 13, 1839.) It is also very properly observed (pp. 24 and 25,) that frost is a very destructive agent in Northern climates, that a large canal requires stronger banks than a small one and that work done in the winter costs more than in summer—all which would have readily suggested itself to individuals about spending their *own* money, even had it escaped the penetration of *their* Engineers for two or three years.

Again, the Croton Water works, nominally city works, though such no further than that the city pays for them, will contribute their mite towards developing the wonderful facility with which government Engineers adapt professional opinions to the wishes of government Commissioners. We must premise that the Water Commissioners had, till last year, delayed fixing on the plan for crossing the Harlem river, the most difficult and important work on the whole line. The plan then brought forward was opposed by certain proprietors of lands on the river, and the Legislature decided unanimously against the Commissioners, though the party to whom they owed their existence had a large majority in one branch—a case nearly unparalleled in New York legislation. The use of iron pipes for crossing, by means of an inverted syphon, the Commissioners' plan, was unnecessary, with the high bridge prescribed by the Legislature, but, as the former are as averse to being interfered with as they are prone to interfere with others, they have announced their intention of complying with the law no further than absolutely necessary, that is, they will keep the aqueduct 12 ft. below grade and use the pipes. We quote their own words.

"The bill as revised, * * * is in substance as follows:—The aqueduct to be constructed over the Harlem river, with arches and piers, the arches in the channel of said river to be at least 80 feet span, and *not less* than 100 feet from high water mark to the under side of the arches at the crown."

"The original design of a high bridge, as designated in our report of January, 1838, required arches of 112 feet in the clear above high water mark, which is 12 feet more than

that required by the act of May, 1839. A bridge therefore, of 100 feet height of arches above tide, will have to be passed by iron pipes, or syphons, to accommodate the ascent and descent of the 12 feet from grade. This bridge will be more economical in its construction, and not subject to so many contingencies, from its less elevation, as the plan originally proposed. The parapets will only be 114 feet in height, which is 17 feet lower than the plan of 1838; and as the arches are thus reduced in height, stone of a diminished thickness may be used. It is proposed to carry the water over the river, at the commencement of supply, by two three feet pipes, adopting the work however, to carry two pipes of four feet diameter, when the city shall require it. *The same arrangement for pipe chambers, and waste cocks, will be required in this structure, as was required for the syphon bridge formerly proposed.*"

"In relation to the bridge, the law prescribes that the arches in the channel *shall be* 100 feet at the under side of the crown, above common high water mark of the river, and *not less* than 80 feet span—conforming in these respects, we are at liberty to make the plans in all others, without restriction from the law."

"The arches of the bridge originally designed to maintain the grade of the aqueduct, were elevated 112 feet above the high water mark of the river, which is 12 feet higher than the *Act requires*. It is obvious, therefore, that 100 feet will not be sufficient to maintain an aqueduct of masonry, but *will require* iron pipes as conduits for the water. This I do not consider an objection, as I am fully satisfied, iron pipes will make the most suitable conduit for the water on such a bridge, and therefore have had a plan prepared, with a view to comply with the law, and avail of the economy and greater permanence from a less elevated structure. The less height required for the arches, and by adopting iron pipes for the conduit, the top of the parapets will be 114 feet above high water mark, which is 17 feet lower than the original plan. The superstructure being lighter than necessary for an aqueduct of masonry, a *diminished thickness* of arch stone may with equal safety be adopted."

We should be pleased to know what diminution in the depth of the arch-stones this change of plan would justify, as well as the saving in cost, which latter, we strongly suspect, it would be difficult to express in the constitutional currency of the United States, without an extension of decimals several places to the right of "mills."

The following extracts, though trifling in themselves, go far to show the estimation in which the profession is held by Government Commissioners.

"Notwithstanding the oversight of the Inspectors and Engineers, the work will, in a few cases, be carelessly performed; and it is only by the correcting influence of these repeated tours of inspection, made by the Commissioners and principal Engineers, that we can be certain the work is performed in a manner which will ensure its stability and imperviousness."

If the citizens of New York have no better guarantee than this, that the work has been faithfully superintended, that 4th of July on which the Croton water will be "regaling the taste and sight of our citizens," (p. 133) will be simultaneous with the milennium.

At p. 255, April number 1839, Railroad Journal, will be found the following cool assertion.

"The locks on the Chenango canal, which are 114 in number, are (with the exception of five stone locks) all of them composite. They were built under the direction of Mr. Bouck, one of the present canal Commissioners, and their average cost was $3,808 50 each."

We shall next be informed that the piers of the Potomac aqueduct have been successfully carried up under the direction of Mr. Forsyth, and that the Thames Tunnel has at length been completed under the superintendence of his prototype Lord Melbourne.

We refer to these circumstances only as effects of the policy of allowing the government to enter into the pursuits of individuals, and not with the design of insinuating that the mortifying reports of many government Engineers are the *cause* of the present state of the profession, but simply to show that they are the legitimate consequences of the pernicious interference of the State Governments with that in which they have no more right to engage, than they have to establish theatres or hotels and then forbid any citizen from competing with them, on the miserable plea, that all the people of

the State are interested in their tavern-keeping monopoly, that it bears equally on all and is, to use the logic of governments, *therefore* just. The pecuniary difficulties in which most of the States who have engaged in railroad and canal speculations find themselves involved, will necessarily break down the entire system of State works, and their complete abandonment will, more than every thing else conduce to the welfare, honor and usefulness of the profession.

The success which has attended the expensive and well constructed railroads about Boston, is the most encouraging facts we have to record, and it is worthy of remark, that the stocks of those roads were the only stocks not affected by the bursting of the biennial bubble, grandiloquently called the "late crisis." The Eastern railroad has been opened to Salem, and the number of passengers is already twice that estimated before the opening of the road, and on which the project was based. The Western railroad has been opened as far as Springfield. The Old Colony railroad is going on rapidly; the Norwich and Worcester is to be opened about new year's day, and the Housatonic railroad some time this month. In this State, the Utica and Syracuse railroad has been opened, and the Syracuse and Auburn railroad put into full operation. In Pennsylvania, the Reading railroad has just been completed, and in Maryland, we believe the Baltimore and Susquehannah railroad has been opened to the public. Two of the above roads have received aid from the State of Massachusetts, but they have all been managed, and, with these comparatively trifling exceptions, have been paid for by individuals. *We do not know of a single State work having been completed, or in part opened during the year* 1839.

In New England they have retained too much of the sturdy independence and common sense of their forefathers, to tolerate the meddling of the government in the affairs of individuals, and we seek in vain for a canal, a railway, a machine shop, a lumber or coal yard owned by a New England State. It has been found impossible to persuade them that they are not as capable as their Transatlantic brethren of managing their own affairs, and the consequence is, that they have the best managed, best constructed, most costly and most successful railways of any State in the Union. An attempt has been made to regulate the sale of spirits, and has proved about as successful as a previous effort to interfere with another article in the "grocery line"—y'clept "tea."

Some little has been done on the State works of New York, by means of the unexpended balances of former appropriations for the enlargement of the Erie canal and the construction of the Genessee valley and Black river canals. There is no little curiosity to know how the first is to be disposed of —not only both parties, but every sane resident of the State, who feels an interest in her honor and welfare, being heartily ashamed of his credulity in believing it either practicable with the means of the State, or useful even if practicable. The money already thrown away on this unrivalled specimen of legislative folly, will do something towards opening the eyes

of the citizens of this State, and a year or two hence we fully expect to find the enlargement as unpleasant a reminiscence in New York as the suspension is in a neighboring State.

The lateral canals of the State of New York cannot with propriety be passed by, being "par excellence" government works in their conception, management, and income. As the official report on the Genessee valley canal has been published in this Journal, (15th April, 1839, p. 253, et seq.,) we will examine the proceedings of the Commissioners with regard to that work, and our readers, by turning over their files, will be enabled to judge of the accuracy of our deductions. The original estimate of the canal was a little less than two millions, but the present estimate is thus stated in the report alluded to.

"The cost of the canal [excluding $314,520 43 for the Dansville branch] is estimated by the canal Commissioners in their recent report, [Assembly Document of 1839, No. 360,] at $4,685,602 36.

"The canal board are not possessed of all the facts necessary to enable them to estimate with sufficient certainty the future revenues of the canal. They fully appreciate its value to the interesting section of the State whose resources will be developed by its completion. In respect, however, to the tolls to be derived from it in the present state of the navigation of the Alleghany river, the board would observe, that in the year 1835, F. C. Mills, Esq., the Engineer who surveyed the route, submitted an estimate to the canal Commissioners of its probable revenues, [Assem. Doc. of 1835, No. 264, page 42,] in which he computed the tolls, independent of its probable contributions to the Erie canal, at $39,129 60. Of this amount, $13,207 was estimated for the tolls on the finer qualities of lumber and other products of the forest, which, it was supposed, would seek the New York market in preference to that on the Ohio and Alleghany rivers. A majority of the canal Commissioners, [including the late acting Commissioner on that canal,] in the report above referred to, have expressed their belief that the amount of $39,129 60, is "greater than will be realized for at least the first few years after the canal is completed."

Now let us translate this into plain unofficial English, such as is used in the every day transactions of common men, not devoid of common sense. It is proposed to construct a work at the expense of the State the cost of which is estimated at two millions of dollars and its *gross* income at less than $39,000, one-third of it to be derived from lumber, which it is well known, will soon be exhausted. The canal is to be 106 miles long, and we know from experience that $39,000 will not meet the ordinary annual expenses, repairs and renewals. We will, however, suppose this sum sufficient for those purposes, then the people of this State are saddled with a "gentleman pensioner," who cannot exist on less than $100,000 per annum. On comparing this, however, with the Chenango canal, it was discovered that the annual deficits of the latter exceeded those of the former by $20,000, and as the march of the Commissioners was "still onward," they at once decided on such an addition to the estimate as should place the Genessee valley canal as far "ahead" of the Chenango, as the latter was in advance of the other "auxiliary" canals. They determined accordingly on spending five millions on this work, which will entail on the State a permanent annual tax of $250,000 at least.

Now, does any man, out of office, believe that the people of the State of New York would have authorised an expenditure of five millions of dollars on a canal which its friends and projectors assert will not yield more than $39,000 gross revenue, merely for the privilege of having their money squandered by a set of canal Commissioners? Before seriously enter-

taining such a project, far less recommending it, they ought to have been able clearly to establish the probability of an immediate income equal to

Annual cost of repairs, renewals and expenses,	$50,000
Interest on five millions of dollars,	250,000
Towards paying off the debt, at least,	100,000
Making the total minimum income,	$400,000

or ten times the estimated income, the latter being in fact, too insignificant in amount to have any material bearing in discussing the value of an undertaking which is to cost five millions.

Suppose that the State of New York, after expending one million on the Chenango canal, had refused to submit to any farther imposition—that canal would have been unfinished—its revenue nothing, in place of $20,000 or an expenditure of two and a half millions, practically speaking, nothing —the State would have saved one and a half million and would only have incurred a permanent annual tax of $50,000 instead of $120,000 which the people of this State are now paying for the glory of owning the Chenango canal. We give an extract from an article which appeared in the Courier and Enquirer of 7th May last, in which the writer undertakes to prove that lateral canals generally will be nearly useless in themselves, and of little value to the main canal. Whatever may be thought of his *reasons*, it is only too true that his conclusions are fully borne out by the actual experience of this State.

"I have never seen any attempt to explain the causes which render the lateral canals unable to pay expenses, though it appears to me to be by no means difficult. The policy which led to the construction of these lateral or auxiliary canals, has no analogy with that which influenced and guided the projectors of the Erie and Champlain canals. The immediate object of the former, was to open to the husbandman the extensive and fertile region of western New York; that of the latter, to bring within reach of the city the forests of the north. Both have fully succeeded—not because there are no other such routes "in the world"—but because they were projected in such a manner as to open the greatest possible extent of country and without reference to mere local interests. With the lateral canals the case is widely different, for it is evident, that the main canal will command the business of the country through which it passes, for a certain distance on each side, this in an agricultural country, will vary from 25 to 40 miles according to circumstances; but, whatever distance be allowed, it is clear, that the portion of the lateral canal contained within these limits, will only receive the contributions of those directly on its banks. If the lateral canals be from 80 to 100 miles apart, it will be found, by a few simple calculations of distances, that a very small portion of the country between the lateral canals and within 40 miles of the main canal will derive any advantage from the lateral canals. Hence the insignificant revenue of the Seneca, Crooked Lake, Chemung and Chenango canals. The two first are in the country directly tributary to the Erie canal, one half of the Chenango canal is liable to the same objection, and the other half and the Chemung canal would suffer from the New York, and Erie railroad had they more than a nominal revenue. The Black river canal proper lies within the influence of the Erie canal, and its extension to the Lake or the St. Lawrence will only furnish a slower more expensive and more troublesome communication between its termini, than the present excellent one by Lake Ontario and the Oswego canal. Lastly, the Genessee valley canal, with the Erie canal on the north and the Erie railroad on the south, bids fair to be second only to the enlargement in disposing of the surplus revenue, or rather in adding to the vast annual deficiencies, which nothing short of an entire change of policy can possibly avert. If the Black river and Genessee valley canals estimated at ten millions, be immediately abandoned, the State will lose about $500,000, which may be considered an anticipation of the payment of one year's deficiencies of these canals when completed, by the immediate forfeiture of which, the State will save a like expenditure per annum in perpetuity, besides the immediate disbursement of a sum nearly equal to the entire cost of the Erie and Champlain canals."

The estimates for these canals have since been reduced, and their probable deficiencies are estimated by Mr. Paige (Sen. Doc. 1839, No. 101, p. 7.) at $450,000, and if the sum now spent on these works does not exceed

two millions, their immediate abandonment will save the State $350,000 per annum—a sum more than sufficient to support the government. We shall have occasion again to refer to the above report, which contains the most sensible view of the public works owned by this State, which has fallen under our observation; and it derives great value from the circumstance that the writer is justly considered one of the ablest men of the party to which we are indebted for the lateral canals and the enlargement, and would naturally be disposed to treat them in the most favorable manner.

It is assumed by Mr. Verplanck and the committee of 1838 that the revenue of the Erie canal will justify an expenditure of 40 millions, and repay the principal in 30 years; while, on the other hand, Mr. Paige, from official documents, undertakes to prove that the revenue will only pay the interest on 15 millions, with every prospect of a permanent debt to that amount. This great discrepancy arises from the fact that Mr. V. adopted the views of the committee of '38, who state in their report, (see Railroad Journal, 1839, p. 87.)

"It will be perceived that the very foundation upon which the financial calculations of the committee are based, is the estimate of the canal Commissioners submitted to the Legislature, in which they state that the Erie canal, within a few years after its enlargement, will produce an annual revenue of $3,000,000. The importance of verifying the accuracy of this estimate will be evident, as any material error would lead to the most injurious consequences."

Mr. Paige on the other hand instead of adopting the conclusions of the Commissioners takes the data on which they either did or ought to have established their income of three millions, and demonstrates that there is no probability of the revenue of the Erie canal reaching this sum till the year 1886 without making any deduction for the partial or total repeal of its monopoly of carrying freight on which exclusive privilege it was shown in a former number that its *entire surplus* revenue depends. The Governor in his late message, as well as the committees of '38 and '39 have placed implicit confidence in the estimated income of three millions, as reported by the Commissioners, while Mr. Paige goes to work as if he neither knew nor cared about any previous calculations on that subject. We have no means of ascertaining why he who knew the merits of the Commissioners so much better than the other gentlemen, should not have yielded the same credence to their statements, but, be this as it may, he has shown clearly that the estimate of three millions gross income from the Erie canal, is utterly unworthy of belief. We must, however, correct one error in this excellent report. It is said, (p.8,) "The Commissioners cannot be regarded as estimating that the tolls would amount to $3,000,000 in 1846 or 1849, but at a period much more remote." This unhappy attempt at exculpation had been anticipated by the report of the late Comptroller which appeared more than three months before the report of Mr. Paige. This officer writes and italicises the remark, (No. 4, Ass. Doc. p. 23,) "*A few years after the completion of the enlargement* may carry us to 1850."—The door of escape for the Commissioners, is therefore closed and we are at liberty to choose as we please,—Mr. Paige's estimate of three millions

revenue in 1886 or the Commissioners' estimate of three millions revenue "*a few years*" before 1850.

After proving the inability of the State to complete the enlargement and the consequent impropriety of any further expenditures, that same Senator, the best lawyer in that body, advocates the enlargement, merely reducing the size from 7 by 70 to 6 by 60, a distinction without a difference—for. an expenditure which is wrong in principle cannot be justified by a diminution of its amount by four millions, or 16⅔ per cent. the precise amount leading to a long debate. The same course was also taken by another gentleman who is well known for the manly stand he has taken against lateral or, as he very properly designates them, "pauper canals," and thus we find two of the most able members of the Senate advocating a work which they know the State can never complete and can never require. As already remarked of the Engineers, it is their misfortune rather than their fault, and the inevitable result of the departure of the government from the high duties of general legislation and its illegal embarkation in the pursuits of individuals, for these same gentlemen, if members of a board of Directors who were expending *their own* money, would be eminent for sagacity, prudence and candor.

The Governor in his first message admits the evil, but does not, in our opinion, go to the root of it, though, as it was necessarily written before entering on office, he could scarcely at that time have supposed it possible that he was approving of a system of works based on official data, which it is now only too clear, were never entitled to his confidence. He very truly observes (Railroad Journal 1839, p. 14.)

"With the extension of our internal improvements, there has been an immense and unlooked for enlargement of the financial operations and the official power and patronage of the canal Commissioners and the canal Board. These operations are conducted, and this power and patronage exercised and dispensed with few of those requirements as to accountability and publicity enforced with scrupulous care in every other department of the government. So inconsistent and unequal are the best efforts to maintain simplicity, uniformity and accountability throughout the various departments, that a greatly mysterious and undefined power has thus grown up unobserved, while the public attention has exhausted itself in narrowly watching the action of more unimportant functionaries. It is a proposition worthy of consideration, whether greater economy and efficiency in the management of our present public works would not be secured; a wiser direction given to efforts for internal improvement throughout the State, and a more equal diffusion of its advantages be effected by constituting a board of internal improvements, to consist of one member from each senate district."

This plan may be attended with some advantages for a short period, but the very nature of the tenure renders it impossible for the State to command the services of agents with the character, capacity, and acquirements of those employed by individuals and companies, as is only too apparent in this State, from the manner in which the enlargement of the Erie canal, and the construction of the Genessee valley and Black river canals have been "got up."

We will briefly allude to some of the Western States. In Michigan, a private company commenced the only important work which can, for many years, be projected in that peninsula—the Detroit and St. Joseph's railroad. The company however, could not proceed with sufficient rapidity, so the

State "assumed the mantle" of Engineer and forwarder general, and commenced the construction of a "Northern Railroad," a "Southern Railroad," one on each side of the company's road now the "Central railroad," and rendered the *system* complete by introducing the "Clinton canal" between the northern and central lines of railway. These four works average very nearly 200 miles each, the sum appropriated or rather the loan authorised for these 800 miles was five millions of dollars, or $6,250 per mile, about one-fourth of the sum required to put them into operation, yet the State has actually entered on the construction of all these works. The result is, that the State, after expending all she has been able to borrow, has only 40 miles of the Central (formerly company's) road in operation, her credit is gone for many years, her farmers must be directly taxed to pay the interest on money expended on works which will never be completed, and the *only* work really required is indefinitely postponed. As in the State of New York, the works projected by the government of Michigan were never thought of by private companies, and it would be as difficult to raise by *private subscriptions* to the stock, 5 per cent. on the probable cost of the "Northern railway," of the "Southern railway," or of the "Clinton canal," as it would be to induce individuals in the State of New York to contribute, as a permanent investment from *their own* means, 2 per cent. towards aiding the government in the construction of the Genessee valley and Black river canals or in the enlargement of the Erie canal—that is—impossible.

The State of Illinois received from Congress a valuable grant of land to aid in the construction of the Illinois canal, a truly national work, uniting the Mississippi with the Atlantic by the St. Lawrence and Hudson rivers. This donation would have enabled the State to complete the canal and the nett revenue might have been expended in aiding private enterprise without the possibility of any tax being necessary even if all the works which they aided should be as unproductive as the "lateral canals" of New York. *Now* they have commenced a "system" of railroads the aggregate length of which is above 1200 miles! besides other works. It is unnecessary to state the consequences which have followed, any further than to allude to the sale of the State stocks in New York at 50 per cent. and to the special session of the Legislature which has been called to devise "ways and means" to enable that State to meet its immediate obligations. There is much anxiety to know the course likely to be persued by the governments of Pennsylvania, Illinois and Michigan, and last, though not least, the city of New York. The Croton water works are exactly as far from completion as when ground was first broken, for the work which, with *any* quantity of money would require more time than *all the rest*, has just been commenced! Had the Commissioners invested the insignificant sum of $2 or 300,000 from their *own* capital this would neverhave occurred, and had this undertaking been left to a company, who should have been bound to expend 20 per cent. on the cost of the work from their *own* means, the citi-

zens of New York would be supplied with "pure" water many years sooner and at one-third of the cost, which now appears inevitable.

In some States, the grand argument will be, that if they can only *complete* the works commenced, a revenue is immediately certain, which will render taxation to pay the interest unnecessary. That the completion of these projects will make the fortunes of many individuals, is well known, but, for the *permanent interests* of the State, the only plan is, to sell out at once with the present comparatively trifling loss It is impossible to pay too much attention to the fact, that the greater part of the works projected by the governments of the different States are not such as will ever be of any essential benefit, and, when we add to this, that they are constructed at twice the cost of similar works in the hands of companies, are generally much inferior in execution and always managed and repaired in the most inefficient manner—we shall be at no loss to account for the present condition of State works in general. The deficiencies of this year in Pennsylvania alone, are estimated at 1½ millions of dollars, and except the Erie canal, there is not a government work in the Union which has paid the ordinary expenses, including of course, interest on cost. If the Erie canal be placed on the footing of the canals of Pennsylvania, that is, if its exclusive right to carry all the freight to and from, western New York, the western States and Upper Canada be abolished, the gross income of the canals of New York will bear a less proportion to the expenditures, than does the revenue of the public works of Pennsylvania to the annual outlays on the Internal Improvements of that commonwealth. Notwithstanding their financial embarrassments, we are happy to say, that no other State in the Union has resorted to this mode of giving a "delusive prosperity" to their public works, and there is some reason to believe that the long reign of "exclusive privileges" in this State, is about to close. By making immediate arrangements for retiring from the construction of canals, the State of New York may yet escape with trifling loss, and with this object in view, the people would readily submit to the present monopoly of freight from the north and west for a few years longer. This appears to us the most judicious course to be pursued in order to avoid a permanent debt, and it certainly offers an honorable retreat from a position in which it is daily becoming more difficult to maintain ourselves.

The great efforts which have been made by the inhabitants on the line of the New York and Erie railroad, under the most discouraging circumstances, to aid in the construction of that undertaking, show that private enterprize is not yet extinguished in this State and we have to record the astonishing and gratifying circumstance, that—notwithstanding the different State governments have made every exertion to absorb all the spare capital of this country and of Europe for their own Utopian schemes—the year 1839 has seen more works completed by *companies* than by *States*. Private energy and enterprise have succeeded where the power of government

has been unequal to the task, and while the star of "free trade" floats triumphantly on the banners of the Bay State, and indeed throughout New England, we will not despair of seeing, in the Empire State, railways as judiciously projected, as well constructed, as profitable to the propretors and ns useful to the public as those of Massachusetts when they shall be left equally free to the people of the former as they always have been to those of the latter State.

Our remarks on the grand question of the session—the railway through the southern tier of counties—will be given in the next number of the Journal, and we conclude this paper with stating our firm conviction, that no new canal will be undertaken by the States of New York, Pennsylvania, or Ohio, and that notwithstanding the complacency with which "repudiation" has been spoken of—we might even say threatened and almost advocated—in a certain high quarter, the people of every State in the Union will continue to act in good faith and fulfil their engagements, even if considerable sacrifices be necessary which is scarcely possible, unless they determine on carrying out, in the present sober times, the mad projects conceived in the frenzy of '36, which have been as injurious to the healthy progress of Internal Improvements, as to the cause of morality, industry, and honest enterprise.

☞ The first paragraph in the above paper was, by accident, in a part of our edition, erroneously printed, it should be as follows:—"Thinking that we could not better close the present volume of our Journal than by offering some remarks on the present state of Internal Improvements and the prospects of the Profession, we have requested a friend who is well qualified as a gentleman of education and an accomplished Engineer, to carry out the idea.

AMERICAN LOCOMOTIVE ENGINES.

A few days since, in company with one of the proprietors, we had the pleasure of a visit to, and inspection of, the very extensive works of Messrs. Rogers, Ketcham and Grosvenor, at Patterson, N. J., for the construction of various kinds of machinery. Our attention was of course principally directed to the shops for the construction of Locomotives, the main building of which is 200 feet long, and 3 stories high; and another of equal length containing near 50 forges, most of which were in operation, notwithstanding the "pressure of the times."

We saw a number of engines in different states of forwardness, and, though the general forms are those of 6 wheeled American engines in general, we were not a little gratified with several minor arrangements, new to us at least, which have been introduced by Mr. Rogers, and to which we will briefly refer.

The wire gauze on the smoke pipe is protected by an inverted cone placed in the axis of the pipe a few inches below the wire gauze. The base of the cone is curled over so as to scatter the sparks over a large portion of the sur-

face of the wire cloth, and to prevent the *top* of the spark catcher from being burnt out before the rest of the wire cloth is materially injured. It also tends to throw the larger sparks down between the pipe and the casing, and will do something towards diminishing this standing reproach.

The truck frames, whether of wood or iron, were admirably stiffened by diagonal braces, and where the crank axle is used, the large frame is very strongly plated, in the manner of Stephenson's engines, the neglect of which till very lately, has been, we are informed, a constant objection to the Philadelphia engines on the Long Island and Troy railroads.

The wheels are of cast iron, with wrought tires; the spokes are round, and they as well as the rims are hollow, except where the crank axle is used, when the rims are cast solid on one side so as to counterbalance the cranks. Our readers will probably remember an article on this subject, in the Journal, No. 7—8, page 244, of the present volume, on "side motion, or rocking," by G. Heaton, where its success on the Birmingham railroad, has been complete. Mr. Rogers balanced his *first* wheels two and a half years since, and two years ago entered a specification, not with the intention of taking out a patent, but to prevent any one else from doing so; and thus depriving the community of the benefit which Mr. Rogers was desirous of conferring; and which we understand other makers are now availing themselves of. The advantages are fully explained in the article above refered to.

When the crank axle is used the eccentric rods and the cranks of the rock shaft are placed on the *outside*, where they are easily got at, and where they are not crowded into the smallest possible space, as with the ordinary arrangement. For this a specification was also entered with the same object as in the preceding case. But we were most pleased with an arrangement of levers to which the eccentric rods are *fastened*, and thus the reversing depends on no contingency, for the rods are *forced* in, and out of gear; a *single* handle is only required to manage the engine much more rapidly, and efficiently than by the ordinary mode.

The boilers are 8 feet long, for an 8 ton engine, with 120 flues; the usual length of the former being, we believe, 7 feet, and the number of the latter, about 80 or 90. By this deviation the area of heating surface is increased, and the heat remains longer in contact with the flues, while the addition to the weight is very trifling compared with the advantages derived from the saving of fuel.

Mr. Baldwin, of Philadelphia, took out a patent some time since for a very ingenious mode of saving half the crank by inserting the wrist into one of the spokes of the driving wheels, and this has been very closely imitated by making one complete crank; and by letting one half of it into a spoke "which is cast larger than the others with a receptacle for that purpose." This latter plan has been adopted by Mr. Rogers and others in this neighborhood, whilst the Boston machinists aim at bringing the two cranks as near together as possible. The relative merits of straight and

cranked axles are so well pointed out in Mr. Woods' paper on locomotives, in these numbers, that we shall merely beg leave to state that the plan of Mr. Baldwin, and its imitation, appear to us to combine the liability to fracture of the crank axle with the loss of heat, the exposure to accident, and the racking of frame and road ascribed to the straight axle, for the only difference is, the thickness of the spoke. The loss of heat is the same in both, and the protection against any *serious* accident is too trifling to be considered, whilst with the cranks as close as possible the cylinders are completely protected. We offer these remarks as own views merely, and with all due deference to the superior skill and science of Messrs. Baldwin and Rogers.

Mr. R. in common with all other experienced machinists with whom we have conversed is decidedly opposed to any increase of width of track beyond 5 feet, with the *present* weight of engine.

As regards the power of the engines, they are able to slip the wheels when the rails are in the best state—this they do in common with all good American or English engines,—consequently any accounts of extraordinary performances would be worse than superfluous, when we *know* that they will do all that any other engine whatever, with the *same* weight on the driving wheels possibly *can* do.

As a last remark, we would observe that there is rather more finish on the engines of Messrs. Rogers, Ketchum and Grosvenor, than we are in the habit of seeing; some parts usually painted black being highly polished. On the whole we consider their new establishment eminently calculated to add to the reputation of American Locomotives, as it has for many years largely contributed to the character of American machinery for the manufacturs of cotton, and other objects.

AMERICAN LOCOMOTIVES.—We give place to the annexed communication in relation to the performance of a locomotive engine, on the New Jersey railroad the more readily as it will serve hereafter as a performance for comparison. It is also acceptable at this time, as the engine is from a shop to which one of the editors of this Journal, in company with two friends made a visit of inspection a few days since, some account of which, will be found in this number of the Journal.

For the American Railroad Journal and Mechanics' Magazine.

GENTLEMEN:—As you seem to take a deep interest in the success of American locomotives, I will give you a statement for your gratification, in relation to a performance on the New Jersey railroad a few days since.

Owing to some circumstances, of which I am not informed, it became necessary for a locomotive on the way from Jersey city to New Brunswick, to take in addition to its own load, the cars attached to another engine which made the number equal to 24 loaded four wheel cars, and with as much apparent ease as could be desired, notwithstanding the grade, for four miles

is equal to 26 feet per mile, stopping on the grade to take in passengers, and starting again with the greatest ease. The average speed on the grade was 24½ miles per hour. This may not be in your estimation anything extraordinary, yet I consider it a performance worth recording, by way of contrast with the *greatest and most extraordinary performance* of a locomotive ever heard of, *in those days*, which occurred on the Liverpool and Manchester railroad in 1829, only ten years ago. *Twenty tons*, on a level road at the rate of 10 miles per hour, was then considered wonderful! *astonishing!!* even in a country famed for its extraordinary discoveries; yet here, only ten years after, we see an engine, built in *this* country, too, taking a load probably equal—cars and tender included—to 120 or 130 tons at the rate of 24½ miles per hour, up a grade of 26 feet per mile. This engine was built, I understand, at Patterson, New Jersey, by Messrs. Rogers, Ketchum and Grosvenor, a concern not yet so well known to this railroad community as manufacturers of locomotives, as they ought to be, or as they will soon be, if they continue to turn out such machines as the one above alluded to.

If such have been the improvements in the *past*, what may they not be, permit me to ask, in the *next* ten years? Pardon me for thus troubling you, but my aim is rather to call attention to the rapid march of improvement in this mode of communication, than to direct attention to any individual, or company—although those gentlemen, in my opinion deserve as manufacturers, much more than I have said of them.

Yours, truly,

Newark, N. J., Dec. 14, 1839. JERSEY BLUE.

Some time since, we were requested to publish the paper of Mr. Woods on Locomotive Engines which we conclude in this number. We have succeeded after some delay in procuring a copy of the Transactions of the Institution of Civil Engineers, and immediately proceeded to furnish such articles as may be of general interest to the Profession, that of Woods' being the first. We hope before another year has passed to be able to extract from the Transactions of an American Institute.

☞ We wish to correct an error which appeared in our advertisement on the cover of the October number. We intended to advertise a "Treatise on Railway Curves, by *J. S. Van de Graaff*, not by the Chev. de Gerstner. It was an error of the printing office, therefore those gentlemen who have written to us, ordering the work, will please set it down as a slip of the *type* not of the pen.

The Agent of the Railroad Journal having returned from his tour, embraces this opportunity of expressing his thanks to the Superintendants of the various Railroads upon which he has traveled for their courtesy in tendering to him the facilities of locomotion "without money and without price." He trusts that on subsequent *professional* visits, he may enjoy similar demonstrations of their good feeling.

LOCOMOTIVE POWER APPLIED TO CANAL TRANSIT.

On the 21st and 22nd of August an experiment was conducted on the Forth and Clyde canal, of a novel and highly interesting nature, by John. Macneil, C. E., and consulting engineer to the canal company. It is well known that the haulage of boats on this canal has hitherto been performed by horses, the rates of speed being for the heavy sloops, brigs, &c., in the London, Dundee, and other trades, about 1½ to 2 miles per hour, when drawn by two or five horses, according to the state of the weather, and for the swift or passenger boats between 8 and 9 miles per hour, on an average when drawn by two horses. The object of the experiment was to ascertain the possibility of using locomotive steam power to draw the boats instead of horses: accordingly, a single line of rails, upon blocks, like an ordinary railway, was laid down for a considerable space along the canal banks, near lock 16; and a locomotive engine and tender, built by Mr. William Dodds, having been brought down the canal and set on the rails on the morning of the 21st, Mr. Macneil, Mr. Johnston, the canal director, and several engineers and gentlemen, being present, the experiment commenced by attaching to the engine the towing-line of the first passenger boat that made its appearance, and which contained upwards of 90 passengers, with their luggage. There was a trifling delay in disengaging the horses and tying the line to the engine, but this was amply compensated when the "Victoria" briskly set off, and almost immediately gained a speed of 17⅓ miles per hour, which she kept up round two curves, and until the termination of the rails made it necessary to stop, amid the cheers of the delighted passengers. This experiment was repeated, during the course of the day, with each passenger boat as it came to the railed space, and with equal success each time. On one occasion a towing-rope, which was much decayed, got foul with a curb stone and broke; but without causing the slightest inconvenience, except about one minute's delay. The engine employed being intended only for a slow trade, was not calculated to go at a greater speed than eighteen miles per hour: but it was the opinion of all present, that with proper passenger locomotives, a speed might be obtained equal to that upon the best railways, few of the latter possessing the advantage secured by the canal bank of a *perfect level* throughout.

The nature of the motion was highly gratifying to all the passengers, being more uniform, steady, and smooth than when the boats were drawn by horses.

Several of the heavy (masted) vessels were also taken in tow during the two days of trial, at the rates of 3, 3½, 4, and 5 miles per hour; and, on one occasion, two loaded sloops, and a large waggon boat, were together attached to the engine, and hauled with ease at the rate of 2¾ miles per hour, while only *one-fourth* of the steam was allowed to pass the throttle-valve.

The foregoing statements render palpably apparent the immense advantages which might be gained by this new adaptation of steam power—a great economy in haulage expenses, as one engine might draw at least 6 sloops, which now would require from eighteen to twenty-four horses, and, if necessary, at double the present speed; and a proportional increase of the important traffic on the canal, which might be reasonably expected.

Passengers would increase in a great proportion, when attracted by economy and speed of transport. The Union canal might be traversed in two hours, and the Forth and Clyde canal in one and a half, instead of four hours and three and a half, as at present, and this by only assuming 16 miles per hour, though more might easily be performed, as the experiments have shown.—*Glasgow Courier.*

THE IRON TRADE.

(Continued from page 340.)

The first works we reach are the Beaufort, which I have already informed you, belong to Messrs. Bailey, and their produce I have included in the return for Nant-y-glo.

Proceeding onwards, we arrive at the Ebbw Vale works, the property of Messrs. Harfords, Davies and Co., who are also the owners of the Sirhowey iron works, situated in the next valley. At Ebbw Vale they have three furnaces in operation, and are building a fourth. They blow one furnace with hot and two with cold air. These furnaces are very productive, yielding 100 tons per week each. At Sirhowey, they have four furnaces in blast, and one undergoing repairs; two are blown with hot, and two with cold air. These furnaces also make about 100 tons per week each, so that at the two works they make about 700 tons of cast iron weekly; the whole of which is converted into bars, rails and rods. Their make of malleable iron is from 600 to 630 tons per week.

One mile lower down the Ebbw Vale, you will find the Victoria Iron Works, recently established under the able superintendence of Roger Hopkins, Esq. These works belong to the Monmouthshire Iron and Coal Company. Only one furnace is yet at work, but another is ready to be blown in, and they are erecting two others. They have just commenced the manufacture of bar iron. I have been informed that they intend building ten additional furnaces, lower down the valley, near to Abercarne. When in full operation, they calculate on making 1000 tons of wrought or malleable iron per week; but this expectation will probably require a few years for its accomplishment.

Having seen all the works in the third valley, we proceed to the fourth, and we here find, first, the Sirhowey works, to which I have already alluded, and next to these, the works of the Tredegar Iron Company. At Tredegar, they have five furnaces in operation all blown with cold air; they are building two others, and contemplate the erection of two more, making nine altogether. They now produce 400 to 450 tons cast iron weekly, which is nearly all made into bars, rails and rods; of these they make about 330 tons per week.

We must now travel on to the fifth valley, in which we find only the Rhymney and Bute Iron Works, belonging to the joint stock company of that name. This is a very extensive and most valuable mineral property, and these works bid fair very soon to rival the largest establishment in South Wales. They have now six furnaces in blast, two blown with hot, and four with cold air; and they are building four others. They make about 550 tons pig iron per week, from which they produce 450 to 480 tons malleable iron in the same period of time.

The whole of the works we have visited since we left Newport, send their iron to that port for shipment, and it is conveyed chiefly down tramroads by locomotive engines and by canals.

We must now take a stretch of five or six miles to the westward, and this will bring us to the hitherto unrivalled establishment of Sir John Guest, Lewis, and Co., at Dowlais. Here you will find fifteen furnaces in full activity, and four others building. I find that I have omitted to note how many were blown with hot, and how many with cold air, but if my memory serves me correctly, I think five with the former, and ten with the latter. These fifteen furnaces make on an average 1350 tons of pig iron per week, nearly the whole of which is converted into malleable iron, say about 1000 tons bars, rails and rods per week. At this establishment they employ upwards of 4000 hands.

The next works we reach are those of the Pen-y-darran Iron Company. They have six furnaces in blast, and one out, making about 400 to 500 tons cast iron per week, and they convert nearly the whole of it into malleable iron, of which they produce about 400 tons per week. I believe the whole of these furnaces are blown with cold air.

We have now, gentlemen. performed a very good day's work, and I am sure you will heartily join me in a proposal to take up our quarters for the night at the Castle Hotel, at Merthyr Tydvil, where I give you my word that you may make yourselves comfortable if you choose. You must take care to muster for breakfast at eight o'clock to-morrow morning, and at nine we will go to see Mr. Crawshay, who is a very early man of business.

The preparation of the morning over, and our arrival having been announced at the Cyfarthfa office, we will now on our way to Cyfarthfa see the Iron Works belonging to Messrs. Crawshay and Sons, and shall no doubt be willingly accompanied by Mr. Williams, their talented engineer. These works are in my opinion the neatest and best arranged in all South Wales, and Mr. Williams I am sure will have pleasure in showing you the whole of the machinery. Amongst other interesting objects for your attention, you may here see the largest pump I ever heard of. The diameter of the working barrel is six feet, and the length of the lift in the barrel is four feet. It pumps up the whole of the river Taff, and the water, after turning all the wheels about the works, is discharged into the bed of the river. This may appear at first view, an expensive way of obtaining power, but experience shows that it is cheaper than erecting a number of small engines, or transmitting power through complicated machinery. Besides the Cyfarthfa, Messrs. Crawshay have the Hirwain works, which are situated about some six miles from Merthyr. At the two establishments there are in the whole fourteen blast furnaces, twelve at work, all blown with cold air, and two inoperative. They make about 900 tons of cast iron per week, and the greatest part of it is made into malleable iron, of which they produce 600 to 650 tons per week.

We next visit the Plymouth Iron Works, belonging to Messrs. Richard and Anthony Hill. Here are seven furnaces, all in blast, and all blown with cold air, making 700 tons of cast iron per week on an average, and from which they make about 600 tons into bars, &c., weekly.

About six miles from Merthyr, over a mountain, are situated the works of the Aberdare Iron Company. They have six furnaces in blast, two blown with hot, and four with cold air, prducing 350 to 400 tons cast iron per week. They make about 220 tons bar iron per week, and the remainder of their produce is disposed of for foundry purposes.

At the Pentyrch Iron Works, near Cardiff, there are two furnaces in blast, blown with cold air, and making about 150 tons cast iron weekly.

The whole of the iron made at the seven last named works is shipped at Cardiff, where a very commodious dock has recently been constructed by the Marquis of Bute, under the superintendence of William Cubitt, Esq., F. R. S., C. E., for the better accommodation of vessels entering that port.

The statistical information I promised to obtain, I found I should have great difficulty in procuring * * * I am compelled to offer you on these subjects the opinion of an excellent friend of mine, who has ample means of forming a tolerably correct estimate. His remarks are very general, and as such I offer them. He says, "To make 1000 tons of bar iron weekly, requires about 4000 persons of every description, but I cannot give you the proportionate numbers to each process. The rates of wages for men range from 12*s.* to 60*s.*, for women 6*s.* to 10*s.*, and for boys 7*s.* to 11*s.* per week."

There is another branch of statistics of the iron trade on which I felt desirous of affording you some information, and in obtaining this I have been somewhat more successful, though it was not procured without very great difficulty—I mean the proportions of the materials used in each process, and the waste of the iron. I am glad to say that I can inform you on these most important points with the utmost exactness. Fifteen furnaces, averaging ninety tons each per week, will produce 1350 tons of cast iron with a consumption of 50 cwt. of coal per ton of iron, inclusive of calcining—say 3375 tons of coal to furnaces and calcining, and to the blowing engines 10 cwt. of coal per ton of iron, or 675 tons. If the furnaces make 1350 tons of cast iron, 100 tons may be deducted for ballast iron. Then refining 1250 tons, at 22 cwt. 1 qr. of pig iron to the ton of refined iron, will produce 1110 tons refined metal with a consumption of 9 cwt. per ton, or about 500 tons of coal weekly for the refineries. 1110 tons of refined metal will yield of puddled iron at 21 cwt. per ton of the metal, and 18 cwt. of coal per ton of iron, 1045 tons with 940 tons of coal; and then the rolling mills at 22½ cwt. of puddled iron and 20 cwt. of coal per ton, will produce 915 tons of merchant bars, or what is called No. 2 iron, with a consumption of 915 tons of coal. * * * * *

Within the last three years, Mr. George Crane, of the Yniscedwyn iron works, has discovered, that by using heated air, he can melt iron ores with the anthracite coal. When I was last in South Wales, I visited Mr. Crane at his works, near Swonsea, in order that I might see and judge for myself of the merits of this discovery. To enable you to form some idea of its value and national importance, I need only inform you that it has added to the available resources of this kingdom, for the purposes of its iron trade, a district sixty to seventy miles long, by six to eight miles broad, abounding with the anthracite or carbon coal, lime, and iron stone; and further, that it has already trebled the value of this extensive mineral property. *

Mr. Crane has yet only one small cupola furnace, in which he uses anthracite exclusively; for firing the other two, he uses as I have before remarked, three-fourths bituminous, and one-fourth anthracite coal; and by using anthracite in this comparatively small proportion, he effects a saving of 12*s.* to 13*s.* per ton in the cost of making iron, and very materially improves its quality. His furnaces also yield a better produce, in proportions of 35 to 50 per cent. His small cupola furnace No. 2, from which, when using cold air and coke, he could obtain only twenty to twenty-two tons of cast iron per week, by being fired with anthracite coal alone, and blown with hot air has produced, on an average of many months, thirty-five tons per week, and the larger furnaces, in which he uses the proportions I have before stated, have increased, the No. 1, from thirty-four to thirty-five tons up to forty-five to forty-nine tons; and the No. 3, from fifty to fifty-five up to sixty-five to eighty tons per week. All his furnaces are very small, and his blowing machinery not so good as it ought to be, hence his very limited produce.

The quality of this iron is very highly spoken—Mr. Crane has received assurances from several parties who had used it for various purposes, that, "for bars it had given great satisfaction:" "for foundry work it was admirable;" that, "in re-melting, it was found very fluid, and at the same time very strong"—a union of qualities most desirable, but rarely to be met with.

With respect to the economy of this new process, Mr. Crane has, on the average of several months, produced the ton of cast iron with the before unheard of small quantity of 27 cwt. of coal, and he entertains the greatest confidence that he will be able to reduce the quantity still further, say

to 22 cwt. His main bed of anthracite coal is eighteen feet thick. I produce a sample of it as obtained from the mine.

The maturing of this most important plan has cost Mr. Crane much time and money and anxiety, and it is to be hoped that he will be most amply repaid for his valuable services.

This new feature in the iron trade soon attracted the attention of capitalists, both here and in London; and the counties of Pembroke, Carmarthen and the western part of Glamorgan, give fair promise soon, at least to rival Monmouthshire and the eastern part of Glamorgan, in the manufacture of iron. I will first enumerate the works already in operation in the Swansea and Neath districts, and then inform you of the extent to which new establishments are being erected and others contemplated.

The Maesteg iron works are worked by Messrs. Robert Smith and Co., with bituminous coal and hot air; they have two furnaces at work, producing from 180 to 200 tons per week of cast iron. A part of this they make into malleable iron, but I an not aware of the exact quantity—perhaps about sixty to seventy tons per week.

The make of Mr. Crane, at the Yniscedwyn iron works, I have already acquainted you with.

The Neath Abbey Iron Company have two furnaces in blast, blown with heated air, and fired with three-fourths bituminous and one-fourth anthracite coal. They make about 160 tons of cast iron per week, the chief part of which is made into castings on the spot, for their very extensive engineering establishment.

The Millbrook Iron Company have two furnaces in blast, producing about forty tons per week, blown with cold air.

The works erecting in the anthracite district are the Venallt, in the vale of Neath, and belonging to our enterprising townsmen, Messrs. Jevons and the Messrs Arthur of Neath. They are carried on under the firm of Jevons, Arthur, Wood and Co. They are building two furnaces, and hope to be in blast by the end of the year. They have a very abundant supply of both kinds of coal and ironstone.

Ystal-y-fera works near Swansea, are also being erected by a Liverpool company, at the head of which stands our spirited and excellent fellow-townsman, Sir Thomas Brancker. This company is building four furnaces and I am told that they intend building four more. Their fuel is all of the anthracite kind.

The Cambrian Iron Company are erecting four furnaces near Pile, on bituminous coal, and I have been informed, intend building four furnaces in the anthracite district. Messrs Mellins & Co. have one furnace near Pile.

The Gwendrath is a new work about to be established by a London company near Swansea, but I could not ascertain the extent to which they intend going. Mr. Crane informed me that he knew of twelve to fourteen new iron works, of from two to eight furnaces each, erecting, and about to be erected, in the anthracite district, the existence of which will be solely attributable to his invaluable discovery.

The aggregate number of furnaces in blast in South Wales, we have found to be 122; out of blast, 7; building, 31; and contemplated, 91; and allowing for the twelve works that Mr. Crane alludes to, as being likely to be erected soon, only five furnaces each, or sixty in all, we thus find that probably within the next five years the number of furnaces in South Wales will be doubled, and number 244. Allowing an average produce of eighty tons per week for each furnace, we have the astounding quantity of 1,015,040, or in round numbers, 1,000,000 tons of cast iron produced in this district alone—a quantity equal to that produced last year in the whole of Great Britain.—*C. E. & A. Journal.*

ON CERTAIN FORMS OF LOCOMOTIVE ENGINES.—BY EDWARD WOOD.

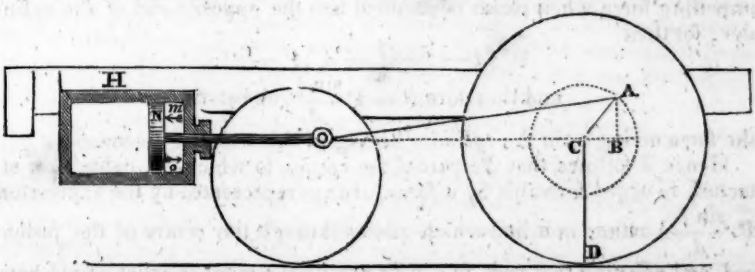
(Continued from page 332.)

ENGINES WITH CRANK AXLES AND WITH OUTSIDE CRANK PINS.

The expense attending the construction of a crank axle, and its liability to fracture unless made with great care and of the best materials, have induced some builders to prefer a form of engine in which the large wheels are propelled by means of crank pins outside the wheels, and admit of being fastened on to a straight axle. The crank axle is thus dispensed with; the machinery is removed from under the boiler, and is consequently more accessible for examination and repairs; the boiler can be placed lower, rendering thereby the centre of gravity lower; and the large axle can be brought several inches nearer the fire-box. These advantages are of importance when they can be obtained without prejudice to the combined actions of the machine. In the present instance such is unfortunately not the case.

When the same shaft is impelled by two separate pistons, it is usual, and indeed it is most conducive to uniform motion, to place the crank pins at right angles to each other; that while one crank is "passing the centres," the other may be in full action. Hence, in engines worked by outside crank pins on the driving wheels, it occurs that at certain periods of the stroke, one *side* of the engine is impelled with the full force of one cylinder, while the opposite has ceased to be impelled by the other; that in fact the line of pull does not coincide with the line of direction in which the centre of gravity of the engine is moving, but alternately passes from one side of it to the other during every revolution of the working wheels. This variation induces an eel-like side motion and causes the flanges of the wheels to strike against the rails, and of course increases the friction. Such action has been always observed in engines of this construction, and is most injurious at high speeds. Being dependent on well known mechanical principles, the amount of the forces producing it may be ascertained.

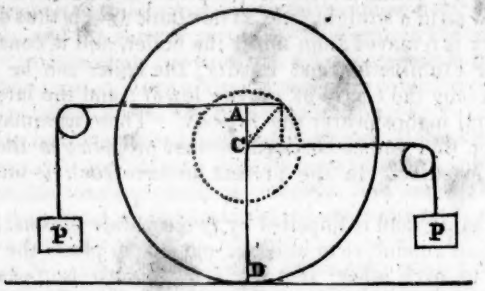
In the following figure, H represents the cylinder attached to the boiler or framing; N the piston; CD the radius of the working wheels; AC the crank arm; AB the sine of the angle made by the crank in moving from the *horizontal* position.



Let steam be admitted behind the piston. Then, as the pressure is equal in every direction, the piston N and the cylinder H are pressed in *contrary* directions with exactly equal forces. Now if the piston be pressed in the direction of the arrow *m*, with a force P, the pin A of the crank must be pressed in the *same* direction with the *same* force;* and again, if the cylinder be pressed in the direction of the arrow *o*, with a force P, the framing of the engine, the pedestals of the axle, and, in fine, the *centre* of

* The consideration of the inclination of the connecting rod, arising from its limited length, as effecting the force transmitted to the crank, is not here entered into, as it would introduce complexity without sensibly influencing the result.

the axle, must be pressed in the *same* direction and with the *same* force. Consequently, it is only by a difference of effect in these two opposite forces, in virtue of a difference of leverage, that any load can be drawn or any motion ensue. Whatever the forces may be, weights may be taken to represent them, and equivalent to them. Therefore to the point A of the lever AD (of which D is the fulcrum) apply the weight P, and to the point C of the same lever apply the weight P.



This arrangement will represent the relation of the two forces. If AC (the sine of the angle) have any value, motion must result *towards* the weight acting upon the longer arm of the lever, and the force producing motion must be equal to the extra weight required to be attached to C to restore the equilibrium.

Let this weight . . . . . $= x$
the semidiameter (CD) of the working wheel . . $= d$
And the angle through which the crank has moved from the horizontal line . . . . . $= \theta$

Then in the case of an equilibrium, the radius of the crank being unity, we have

$$P.\{d + \sin\theta\} = d.\{P + x\}$$

$$\text{and therefore } x = P.\frac{\sin\theta}{d}.$$

In like manner it may be shown, that this is also the expression for the impelling force when steam is admitted into the opposite end of the cylinder; for then

$$P.\{d - \sin\theta\} = d.\{P - x\}$$

$$\text{and therefore } x = P.\frac{\sin\theta}{d}, \text{ as before,}$$

the force acting upon the *cylinder* having in this case the ascendency.

Hence it follows, that the part of the engine to which the cylinder is attached, is urged forwards by a force (always represented by the expression $P.\frac{\sin\theta}{d}$) acting in a line which passes through the centre of the piston-rod, and affecting that part in a way precisely similar to what would have resulted, had an equal but *independent* force been applied from *without*. For it is clear that the extra weight or force x acts in the vertical plane in which the centre lines of the piston rod, connecting rod, and crank pin are situate. If this plane coincide with that which passes through the line of direction of the centre of gravity, a direct impulse will be given to the engine, and no tendency will exist to disturb the equilibra of the parts adjacent to either side of that plane. But should the two planes *not* coincide, a disturbance will take place, greater or less, according to the magnitude of the interval which separates them. This disturbance would, however, be

counteracted, and the equilibrium restored, by applying on the *opposite* side of the central plane, at an equal distance, an equal force. A locomotive engine provided with cranks at right angles, is impelled by two separate forces, acting at *equal distances* from the central plane. But these two forces, although equal to each other in the aggregate effect produced during one revolution of the crank, are by no means equal during every instant of the time in which the revolution is performed. They are, in fact, very dissimilar; and it is, therefore, by their difference at any given moment that the engine is urged to move out of the right line. The force impelling one side of the engine has been shown to be

$$P.\frac{\sin\theta}{d}, \text{ or } \frac{P}{d}.\sin\theta.$$

in which expression it will be observed that P and d are constant, sin θ being alone variable; and that consequently the forces acting upon the sides, are respectively as the sines of the angles, and their *difference* equal to the difference of the sines multiplied by $\frac{P}{d}$.

For instance, put P = 5000 lbs.

$d = 3$ (the radius of crank being equal to unity.)

Then $\frac{P}{d} = 1666$ lbs., which, multiplied by the difference of the sines, gives the *excess* of force by which one side is impelled above the other.—Assuming the crank arm on the right side of the engine to be 90° in advance of that on the left, we perceive that, during one revolution of the axle, the force upon the *right* side has been twice equal to zero, while that upon the left has been at a maximum, or 1666 lbs. and that the force upon the *left* side has been twice equal to zero, while that upon the right side has been at a maximum.

It remains to explain what amount of side pressure is conveyed to the wheels under these circumstances. For this purpose it may be first assumed that the engine is placed upon a perfectly level plane, and is free to move sidewise without friction.

Let W = the tractive power exerted.

a = the force given out by one cylinder at some assigned moment.

$a+b$ = the force given out by the other cylinder at the same moment.

r = the distance between the central plane and the plane which passes through the axis of the cylinder, piston rod, &c., (both planes being vertical and parallel to each other.)

s = distance from the centre of gravity to the hind axle.

s' = ditto from ditto to the fore axle.

Then, in the case of an equilibrium, we have $W = a + a + b$. a and a being equal, and acting at equal distances from the central plane, will not tend to produce side motion; the unbalanced force b will alone have that effect, and will cause the engine to turn about its centre of gravity. Let this tendency to turn be resisted by a force w, applied at right angles to the engine at a point opposite the centre of the hind axle; and by a force w', applied in a similar manner, but on the other side, at a point opposite the centre of the fore axle. Then when there is an equilibrium,

$$br = ws + w's';$$

also, $w's' = ws$;

therefore, $br = 2ws$,

whence, $w = \frac{1}{2}.\frac{br}{s}$

$$w' = \frac{1}{2}.\frac{br}{s'}.$$

Suppose b=1666 lbs.; r=3 feet; s=1 feet; s'=5 feet; then w, or the side pressure upon the hind wheel, is 2499 lbs.; and w', or the side pressure upon the fore wheel, is 499 lbs.

The side pressure is resisted by the adhesion existing between the surfaces of the rail and wheel by the conical shape usually given to the tire, but especially by the flanges of the wheels. As in practice it is necessary to allow of some play between the flange and the side of the rail, a prejudicial swinging motion must arise. The nearer the cranks are brought to the centre of the engine, the more steady will its motion become; and when the line of application of the power coincides with the vertical plane of the centre of gravity, (as would be the case were the crank in the middle of the axle,) the force producing side motion altogether disappears.

On these grounds, outside cranks are undesirable, not only as tending, by the irregular motion they produce, to injure the wheels and axles, and to oppose considerable resistance to forward motion, but also as likely to prove injurious to the road. But outside cranks, in themselves objectionable, involve outside cylinders, and thence arises another reason for their rejection. Serious inconvenience must frequently arise from having the cylinders so directly exposed to the shocks and blows which their external position in the framing renders them liable to receive. In cases of serious collision, the front part of the framing is often broken. When the cylinders are inside, they are protected and sustain little or no damage. With outside cylinders the consequences have been more disastrous. The cylinders have been broken, and the adjustments of the machinery disturbed, to a degree which has required much time and labor to repair. To withstand the strains produced by the reciprocating action of the pistons, and the minor blows of daily occurrence, a strength of framing much greater than that of any inside cylinder engine is found necessary.

COUPLED AND UNCOUPLED ENGINES.

The unfounded apprehension entertained at an earlier, though comparatively recent, period in the history of locomotion, that engines would be unable to advance with any considerable load, without some mechanical contrivance for promoting adhesion or resistance between the wheel and the rail, has now been removed; the simple force of adhesion between the clean surfaces of iron having been found sufficient to resists the power applied to the driving wheels for effecting forward motion.

The force of adhesion, when the surfaces are in a clean state, (either thoroughly wet or thoroughly dry,) equals at least one-fifth of the insistant pressure. Under such circumstances, an engine, the weight upon whose driving wheels is *five tons*, would exert a tractive power of *one ton*, or 2240 lbs. without slipping; in other words, would draw a load of 250 tons upon a level railway. A favorable state of the road is, however, far from being constantly obtainable. In a damp atmosphere the rails are often partially wet without sufficient moisture to wash them clean, and the adhesion may be reduced from one-fifth to one twenty-fifth of the insistant weight, and the engine may become unable to advance without slipping, with a load equal to more than one-fifth of what may be considered its maximum.—The usual load of a passenger train on the Liverpool and Manchester line seldom amounts to more than one-third or one-fourth of what the engine is able to draw at a slow speed upon any portion of the road; (with the exception of the incline of 1 in 96;) the power, as estimated *merely* by the dimensions of the cylinder, crank and wheels, and by the full pressure of steam being three or four times greater than the resistance to be overcome. The question of *speed* bears no reference to the power thus considered, being solely dependent upon the *rate* at which steam of the required

$w = \frac{1}{2} \cdot \frac{}{s'}$.

elasticity is generated. The adhesion, therefore, does not often prove less than sufficient for such trains, and it is on this account that the delays of passenger trains by the slipping of the engine wheels are comparatively trifling. Upon railways whose gradients are less favorable, or the loads heavier, the inconvenience from slipping may be expected to be increased. The application of a convenient and safe method of coupling would in these cases be very desirable.

In the transport of merchandize, the difference between a speed of 16 and 25 miles per hour is not of much object, and the slower rate is adopted as being on every account more economical. The engine being now able to take a heavier load, obviously and indispensably requires more adhesion. Luggage engines, and those that assist at the inclined planes, have therefore been provided with the means of coupling the wheels, or of rendering the whole (or nearly the whole) weight of the engine available in producing adhesion. For this purpose, the fore wheels and the driving wheels are made of equal diameter, and both pairs are so united by outside connecting rods that the one cannot turn independently of the other. This arrangement is simple, and on the whole very effective, but is nevertheless open to objections, which especially render its application to passenger engines unsafe.

1. There arises frequently great extra friction from strains, occasioned by unequal wearing of the wheel tires, and from want of proper adjustments in the connecting rods.

2. There is considerable difficulty in passing round sharp curves.

3. There is risk of the connecting rods *breaking*. Such accidents are not of uncommon occurrence. Engines have been occasionally thrown off the rails by the end of the connecting rod striking the ground.

4. High speeds are very liable to derange the connecting rods, and are therefore unsafe.

5. A coupled engine *when it slips* is subject to a very violent side motion, and a great strain is thrown upon the wheels, the outside cranks and the rods.

6. In a clean state of the road the connecting rods are not wanted, and only act as an incumbrance.

7. The fore wheels being of equal diameter with the driving wheels, the piston rod must work under the fore axle; the cylinders are then placed lower and in an inclined position. The *weight* of the fore wheels is likewise increased.

A mode of coupling, the invention of Mr. Melling, of this railway, has been applied successfully during the last year and a half upon the "Firefly" engine, which promises to remove the preceeding objections, and is therefore peculiarly adapted to passenger engines. Whether this plan may as effectually prevent slipping as that now in common use, is a point which perhaps still remains to be decided: but that it is effective in a great degree cannot be denied. Having had occasion to make several experiments bearing upon the subject, I shall give a brief outline of the results.

The apparatus consists of a small independent wheel, which can be pressed downwards, with considerable force, between the outer rims or tires of the driving and the fore wheels and consequently can be made to transmit to the rim of the fore wheel the power given out at the rim of the driving wheel. The requisite force is obtained by opening a communication between the boiler and a small cylinder, the piston of which with the assistance of suitable levers, is made to press the coupling wheels downwards.

Adhesion between the wheel and the rail is obviously proportional to the weight which exerts its pressure upon the two surfaces. When the rails

are in a dry state, the weight upon the driving wheels produces adhesion sufficient to enable an engine to advance with a maximum load without slipping; but a slight greasy moisture diminishes the adhesion, and the wheels slip without advancing.

Under the last mentioned circumstances, the driving wheels alone of an uncoupled engine can slip, and no benefit would accrue from the weight sustained by the fore wheels. On the other hand, the driving wheels of an engine coupled with connecting rods cannot slip without at the same time causing the fore wheels to revolve. In this case the full benefit of the weight upon the fore wheels is obtained. It will, then, be evident that the method of coupling by a "contact" wheel, can only produce the extra adhesion in virtue of a transmission of the power from the driving wheel to the fore wheel, through the medium of the resistance opposed to the friction of iron *sliding* upon iron at the surface of the small coupling wheel. Such resistance, when the surfaces in contact are clean, is known to be very great and would be sufficient to turn the fore wheels were they resting upon a slippery rail. But the greasiness of the rail is in some measure transferred to the wheel itself, and necessarily diminishes the adhesion of the coupling wheel. It might then be expected, that, while this wheel would in every case increase the total adhesion, it still would not exert a degree of power capable of overcoming the adhesion between the fore wheels and the rails. However, on reversing the engine suddenly, and applying the coupling wheel, I have frequently observed the fore wheels completely locked and sliding upon the rails. The following experiments were made with the view of ascertaining roughly, what difference in the amount of slipping the removal of the coupling wheel would produce, under equal conditions of load. The load assigned to the engine was that of pulling its tender with all the wheels locked. A slippery part of the road was chosen and two stakes were there driven into the ground, 320 yards assunder. Proper counters were also attached to the wheels for registering the number of revolutions. The engine being brought opposite to one of the stakes, the regulator was opened to its full extent.

EXPER. 1. Coupling wheel *in action.*
Large wheels made 92 revolutions.
Small ditto 87 ditto.

EXPER. 2. Coupling wheel *not in action.*
Large wheels made 136 revolutions.
Small ditto 87 ditto.

EXPER. 3. Coupling wheel *in action.*
Large wheels made 65 revolutions.
Small ditto 85 ditto.

EXPER. 4. Coupling wheel *not in action.*
Large wheels made 337 revolutions.
Small ditto 85 ditto.

Had the driving wheels not slipped, they would have made only 59 revolutions in the 329 yards; so that in the

1st experiment 33 revolutions were slipped.
2nd ditto 77 ditto ditto.
3d ditto 6 ditto ditto.
4th ditto 278 ditto ditto.

The first and third experiments, being those in which the wheel was applied, are evidently the most favorable.

By this method wheels can be coupled whatever be their respective diameters, under the condition, which must obtain in every locomotive, of an equality of velocity in the revolving surfaces. The coupling wheel is

under the entire control of the engine man, and can be applied or removed at pleasure, without the necessity of stopping or even checking the motion of the engine. It is, however, subject to one mechanical imperfection. The tires of the engine wheels are conical, and therefore admit of connection only by the frustrum of a cone whose apex points in an opposite direction. Hence the outer edge of the tire iron revolves with a less velocity than the inner edge, while the relative velocties of the outer and inner edges of the coupling wheel are precisely reversed. A perfect contact between the two surfaces throughout their entire width would occasion much friction by the sliding of the parts upon each other, and indeed would be otherwise objectionable on the ground of lessening adhesion, experience having well established the doctrine, that the narrower the bearing surface, the greater is the adhesion under equal pressures.

It became an interesting matter of inquiry to ascertain the amount of impeding friction produced by the full application of the coupling wheel, to determine what proportion of the useful effect of the engine would be absorbed. A set of experiments, conducted in different ways, viz: by the angle of friction, by the dynamometer, and by a maximum load, were carefully made. The results agreed very closely, and the mean obtained gave

120 lbs. as the absolute friction of the engine when *uncoupled;* and

200 lbs. as the absolute friction with the coupling wheel in full action.

The difference, 80 lbs., being due to the method of coupling. It may be observed, that 200 lbs. is scarcely less than the absolute friction of an engine coupled in the ordinary manner. When, however, we take into account the difficulties attending the adjustment of the connecting rods, whether in keying the brasses so accurately as to enable the cranks to pass the centres without strain; or in turning, and after they have been turned, preserving a precise equality in the diameters of the wheels, the conclusion at which we arrive does not seem premature, that on an average of circumstances the diminution of useful effect is less upon the system of coupling by contact, than upon that of coupling by connecting rods. If the rails be dry, the coupling wheel is lifted off and remains idle; but connecting rods *must* continue working, and then act only as an incumbrance. In damp weather only can the two modes come into competition. Whatever tendency to slip exists in the driving wheels must be transferred to the fore wheels. In the one case a constant pressure produces a constant resistance; in the other a variable resistance is occasioned by a friction of the joints of the connecting rods, increasing with every addition to the weight of the load.

EDWARD WOODS.

Manchester, Jan. 8, 1838.

THEORY OF THE STEAM-ENGINE.

(Continued from page 348.)

Section VI.—Of the conservation of the maximum density of the steam for its temperature, during its action in the engine.

When an engine is at work, the steam is generated in the boiler at a certain pressure; from thence it passes into the cylinder, assuming a different pressure, and then, if it be an expansive engine, the steam after its separation from that of the boiler, continues to dilate itself more and more in the cylinder, till the end of the stroke of the piston. It is commonly supposed that, during all the changes of pressure which the steam may undergo, its temperature remains the same, and the consequent conclusion is that, during the action of the steam in the engine, its density or relative volume follows

the law of Boyle or Mariotte; that is to say, the relative volume varies in the inverse ratio of the pressure. This supposition simplifies indeed the formulæ considerably, but we shall presently see that it is contrary to experience; and therefore it becomes necessary to seek what is the true law, according to which the steam changes temperature in the engine, at the same time that its pressure changes. And as calculations relative to the effects of steam, depend essentially on the volume it occupies, we must seek also what changes that volume undergoes, by reason of the variations of temperature and pressure, which take place in the steam during its action.

We shall then substitute for the relation precedently indicated, another more real, and, what is essentially necesary to calculate the effects of steam with accuracy, deduced from the facts themselves.

We have just said that the calculations relative to steam-engines suppose the steam to preserve invariably its original temperature, which allows the application of Boyle's or Mariotte's law to all the changes of density or of pressure it may undergo. However, as it is known that elastic fluids never dilate without cooling in some degree, this supposition obviously could not be realized, but on condition that the steam have time to recover from the bodies with which it is in contact, supposed to be sufficiently heated, the quantity of caloric necessary to restore its temperature, after expansion, to the same degree at which it was before. Now, the rapidity of the motion of the steam in the cylinders and the pipes will not suffer the admission of such an hypothesis.

To obtain satisfaction on this head, in a numerous series of experiments which will be found related in the second edition of our TREATISE ON LOCOMOTIVES, we adapted to the boiler of a locomotive engine, a thermometer and an air-gauge or manometer; we applied also two similar instruments to the pipe through which the steam, after having terminated its action in the engine, escaped into the atmosphere; and observed their simultaneous indications. The steam was generated in the boiler at a total pressure varying from 40 lbs. to 65 lbs. per square inch, and escaped into the atmosphere at a pressure varying, according to different circumstances, from 20 lbs. to 15 lbs. per square inch. Had the steam preserved its temperature during its action in the engine, it would have issued forth with the pressure, for instance, of 15 lbs. per square inch, but with the temperature proper to the pressure at which it had been formed, that is, 65 lbs. per square inch. Now, nothing like this took place; during some hundreds of experiments wherein we observered and registered these effects, we found invariably that the steam escaped precisely with the temperature suitable to its actual pressure; so that the thermometer, graduated to indicate the pressure in the steam of maximum density, gave identically the same degree of pressure as the air-manometer, and accorded equally with a siphon-manometer, which we had superadded to the apparatus at the point of the outlet of the steam. The steam then was generated in the boiler at a very high pressure and quitted the engine at a very low one; but, on its leaving the engine, as well as at the moment of its production, the steam was at the same temperature that it would have had, if immediately formed at the pressure which it had at the moment of the observation.

Consequently, we are to conclude from these experiments, that during its whole action in the engine, the steam remains in the state of steam at the maximum pressure or density for its temperature. Hence it results that, when the pressure of the steam changes in the engine, its temperature changes spontaneously at the same time, and *vice versa*; so that they always preserve the mutual relation which connects the pressures and temperatures in the steam in contact with the generating liquid.

Now, we have shown in the fourth section of this chapter, that, with regard to steam in contact with the liquid, the *relative* volume, that is the ratio between the volume of the steam and the volume of an equal weight of water, may be expressed in terms of the pressure by the following very simple formula,

$$\mu=\frac{1}{n+qp}, \quad \ldots \quad (a)$$

in which μ is the relative volume of the steam, p the pressure expressed in pounds per square foot, and the constant quantities n and q, have, according to the engines considered, the numerical values already indicated, viz.:

Condensing engines:

$n=\cdot00004227 \ldots q=\cdot000000258;$

Non-condensing engines:

$n=\cdot0001421 \ldots q=\cdot00000023.$

This relation, then, will be applicable to all the states of the steam during its action in the engine.

Now, according to equation (a), if we suppose that a certain volume of water represented by S, be transformed into steam at the pressure p, and that we call M the *absolute* volume of steam which will be produced by it, we shall have,

$$\mu=\frac{M}{S}=\frac{1}{n+qp}.$$

If afterwards the same volume of water be transformed into steam at the pressure p, and that we call M′ the *absolute* volume of the resulting steam, we shall have also,

$$\frac{M'}{S}=\frac{1}{n+qp'}.$$

Consequently, between the *absolute* volumes of steam which correspond to to the same weight of water, we shall have the definitive relation,

$$\frac{M}{M'}=\frac{\frac{n}{q}+p'}{\frac{n}{q}+p}; \quad \ldots \quad (b)$$

that is to say: the volumes of the steam will be, not in the inverse ratio of the pressures, as was supposed in admitting Boyle's or Mariotte's law, but in the inverse ratio of the pressures augmented by a constant quantity.

The last equation gives also

$$p=\frac{M'}{M}\left(\frac{n}{q}+p'\right)-\frac{n}{q} \quad \ldots \quad (c)$$

And the two equations (b) and (c) will serve to determine either M, or p, according to the one of these two quantities, which will be unknown.

These relations then must be substituted for that of Boyle or Mariotte, which is not applicable to the operation of steam in the steam engine.

As, in all calculations relative to the effects of steam engines, the volume occupied by a given weight of steam forms the important element of calculation, it is very obvious that the use of the above principle; that is, of the *conservation of the maximum density of the steam for its temperature*, during its action in the engine, and the formula by which we have represented it, will tend to the avoiding of many considerable errors in the results.

If we consider, for instance, an engine in which the steam generated at the pressure of 8 atmospheres, or 120 lbs. per square inch, shall expand to 10 lbs. per square inch; then in the usual mode of calculation, it will be supposed that the steam during its expansion, will preserve its temperature

and that its volume will vary in the inverse ratio of the pressures. The volume of the steam at the pressure of 120 lbs. per square inch is 249 times that of the water which produced it. If its temperature remained unchanged during its action in the engine, its volume after the expansion would become

$$249 \times \frac{120}{10} = 2988.$$

The supposition, then, amounts to admitting that under the pressure of 10 lbs. per square inch, the volume of the steam would be 2988 times that of the water. Now, from accurate tables, this volume is 2427. An error, then, is induced of $\frac{1}{5}$ on the real volume of the steam, that is to say, on the effect of the engine; and this error will be almost entirely avoided by the use of our formula, since it gives in this case 2417, instead of 2427, that is to say, it differs inconsiderably from the true volume of the steam.

Let us, however, add, that in slight differences of pressure, such as take place in some engines, the error may become scarcely noticeable.

CHAPTER III.—GENERAL THEORY OF THE STEAM-ENGINE.

ARTICLE I.—OF THE EFFECT OF STEAM-ENGINES, IN THE CASE OF A GIVEN EXPANSION, WITH ANY VELOCITY OR LOAD WHATEVER.

Section I. *Of the different problems which present themselves in the calculation of steam-engines.*

After having exposed succinctly, in the first chapter of this work, the manner in which we conceive the mode of action of the steam in steam-engines, we now proceed to the full development of the theory of which, as yet, we have given but a very imperfect sketch, and to the solution of the different problems that may occur in the working or in the construction of steam-engines.

We distinguish three cases in the working of a steam-engine; that in which it works at a given expansion of the steam, and with any load or velocity *whatever;* that in which it works at a given expansion, and with the load or velocity proper to produce its *maximum useful effect with that expansion;* and lastly, that in which the expansion having been previously regulated for the most favorable working of the steam in that engine, it is loaded, moreover, with the most advantageous load for that expansion;—which consequently produces the *absolute maximum useful effect* for that engine.

We have already observed, that the three fundamental problems of the calculation of steam-engines consist in finding successively the velocity, the load, and the evaporation of the engine. After the solution of these three problems, that which first presents itself as a corollary to them, consists in determining the useful effect of the engine, which determination itself may be expressed under eight different forms, viz., by the number of pounds raised one foot by the engine in a minute; by the force of the engine in horse power; by the effect of 1lb. of coal; by the effect of one cubic foot of water evaporated; by the number of pounds of coal or of cubic feet of evaporated water, necessary to produce one horse power; and finally, by the number of horses represented by each pound of fuel consumed or by each cubic foot of water evaporated. We have, then, to give successively the means of solving these different questions.

For the sake, however, of greater precision, the following are the problems we purpose to solve in a general manner, for each of the three cases above noticed, and for the different kinds of engines.

1. Given the load of an engine, in other respects fully known, to determine what velocity the engine will assume with that load.

2. Knowing, on the contrary, the velocity at which it is intended to work the engine, to determine what load it can set in motion at that velocity.

3. Given the load to be moved by the engine and the velocity at which it is to move, to determine what evaporation the engine must be capable of, and consequently the dimensions requisite for the boiler, in order to produce the desired effects.

4. The evaporation, the pressure, and the dimensions of an engine being known, to calculate the useful effects it will produce in a given time, at a determined velocity or with a determsned load.

To determine, from the same data, the horse power of the engine.

Having the same data, and moreover the consumption of fuel per hour to find successively :—

The useful effect the engine will produce per pound of fuel.

The useful effect the engine will produce per cubic foot of water evaporated.

The weight of fuel that will produce one horse power.

The volume of evaporated water that will produce one horse power.

The horse power which will be produced by the consumption of one pound of fuel.

The horse power which will be produced by one cubic foot of water evaporated.

These various problems will be solved in the three cases mentioned above. Consequently in the two latter, the question will be to calculate the velocity, the load, and the effects, corresponding to the *relative* or *absolute maximum useful effect of the engine.*

In the ordinary theory of steam-engines, the solution of three questions only had ever been attempted ; namely, to determine the load, the evaporation, and the useful effect (under different forms ;) and we have seen that their solution was defective. As for determining the velocity of the engine for a given load, no solution had ever been proposed ; and the very nature of the theory employed did not permit of distinguishing in the engine, the existence of the three cases which do in reality occur. It is possible, then, that the questions we have just presented may at first appear rather obscure, expressed as they are in general terms, and inferring relations under which it is not usual to consider steam-engines ; but they will be explained as we proceed, and their indispensable necessity will be felt, to calculate with accuracy either the proportions or the effects of steam engines of every kind.

(To be continued.)

SPEED ON RAILWAYS, A COMMUNICATION BY THE COMPT DE PAMBOUR TO M. ARAGO.

The resistance of the air to bodies which travel through the atmosphere with a rapid motion, having given room to some persons to imagine that locomotive engines could never attain a very great velocity on railways, I think it will be interesting to you to know, that in an experiment I have just made (on the 3rd August,) upon the Great Western railway between London and Maidenhead, we attained a speed of 55·4 English miles per hour. The experiment was performed by the "Evening Star" locomotive manufactured by Mr. Robert Stephenson, of New Castle ; it has wheels of 7 feet diameter, and drew only the tender loaded with 8 persons. It maintained easily, during 7 or 8 miles, a speed of 45 miles per hour, afterwards

for a distance of 3 or 4 miles, a speed equal to 48 miles per hour, and at last, two miles were travelled over, each in one minute and five seconds, which gives a velocity equal to 55·4 miles per hour. Although this very rapid motion gives one the idea that we are left to the mercy of chance, by the difficulty there would be to stop the engine in time, in consequence of the almost complete instantaneousness with which obstacles present themselves, to overcome this difficulty it would be necessary to increase the inspection of the state of the railway, and to employ rapid means of transmitting to a distance, by signals, the state of the road.

With the engine employed for the experiment we were not able to go beyond the speed stated above, because the pump was not sufficiently large to feed the boiler, consequently we were obliged to suspend the vaporisation, and to decrease the speed, until the boiler was again replenished with water; but there is no doubt that in only enlarging the diameter of the pump and feeding pipes, we might be able to maintain the greatest speed for a long distance—and even to go beyond it. Speed equal to what I have reported has already been mentioned in some journals, but as these statements are often made upon heresay evidence only, I have thought that it would be useful to you to be informed of it by the experimentalist himself. I have not given here the different dimensions of the engine, because my only object now is to make known the facility that there is in attaining considerable speed. I shall only add that the Great Western railway is sensibly a level.

Mechanical Brick Making.—At the meeting of the British Association at Birmingham, Mr. Cottam exhibited a model of a brick and tile making machine invented by the Marquis of Tweeddale, by which it was stated 30 bricks a minute, or nearly 30,000 bricks a day, might be made, while a good moulder could only mould from 5000 to 8000 a day. The clay was put into the machine at one end, and passing between two rollers was rolled into a long bar, which was cut into the required length of the bricks by a cutter worked by the same wheel-work. The bricks, on coming out at the opposite side of the machine, were carried by it to a distance of 200 yards, thereby saving a great amount of time and money in carrying, an operation usually performed by boys and women. As a proof of the superiority of the machine-made brick, it weighed 8 1-4 lbs., while a common brick weighed only 5 3-4 lbs., and the machine-made brick carried eight times the weight which the common brick would sustain.

A new method of preserving iron work from rust has been communication by M. Paymen to the French Institute. It consists in plunging the pieces to be preserved in a mixture of one part concentrated solution of impure soda, (soda of commerce,) and three parts water. Pieces of iron left for three months in this liquid had lost neither weight nor polish; while similar pieces immersed for five days in simple water were covered with rust.

Roman Pavement.—Lately in excavating the ground for rebuilding the hall of the Worshipping Company of Dyers, in College street, Dowgate hill, at 13 ft. 8 in. below the level of the street, and just above the gravel, the workmen came to the remains of a Roman pavement, formed of small pieces of tiles about an inch square, bedded apparently on fine concrete.

Suspension Bridge across the Danube.—The patent for the construction of this bridge is granted to the Baron Signa, and will be proceeded with immediately. It will cross the Danube between Pesth and Ofen, and will connect Hungary with Austria. Mr. Tierny Clark, who built the Hammersmith Suspension bridge, is to be the engineer.—*Railway Mag.*